

SIMULATIONS OF EGALITARIAN SOCIETIES WITH COMPARISON TO OBSERVATIONS

S.M. YOUNGER,* Los Alamos National Laboratory, Los Alamos, NM

ABSTRACT

Multi-agent simulation was used to study normative behavior in model egalitarian societies (i.e., those without centralized leadership). We simulated populations of 100 agents in finite landscapes, such as one might find on isolated islands. Agents moved in search of food, produced offspring, and ultimately died of hunger or old age. They remembered and shared action-generated reputations of other agents, and these reputations influenced future interactions. The aggregate of agent reputations, called mutual obligation, monitored sharing-generated social cohesion. Various methods of sharing, the effect of tolerance to theft, and the effect of homicide and revenge were simulated. We found that social cohesion was maximized for indiscriminant sharing rather than sharing designed to optimize individual fitness. When reputation was a factor in mate selection and when some tolerance of past transgressions was allowed, populations were stable only for very low or very high values of tolerance. In between, there was a high probability of population collapse. Societies optimized their probability of success by excluding a major segment of the population from homicide and revenge. These results are compared to observations of a number of egalitarian cultures around the world.

Keywords: Egalitarian society, multi-agent simulation, reciprocity, violence

INTRODUCTION

Egalitarian societies offer interesting test cases for social simulation in that they are typically small, exist in relative isolation, lack complex political structures, and demonstrate a variety of cultural patterns. Typical egalitarian societies number in the few hundreds of persons, well within the reach of many simulation techniques. The isolation of desert bands or of island peoples makes boundary conditions more straightforward than when several cultures closely interact. Social behavior in egalitarian cultures is dominated by the individual agent, inviting the systematic study of various rules of behavior or other agent models. Finally, egalitarian societies around the world offer substantial cultural diversity so as to constitute a rich basis of comparison for simulations.

Significant ethnographic data exist for egalitarian societies in a variety of environments, from resource-poor deserts to resource-rich tropical islands. Most important, several anthropologists have undertaken to collect data that permit alternate social models to be compared on an objective footing. These comparisons present an excellent opportunity to test agent models against real-world data.

* *Corresponding author address:* Stephen M. Younger, Los Alamos National Laboratory, Mail Stop B210, Los Alamos, NM 87545; e-mail: syounger@hawaii.edu.

One of the complications of such comparisons is that the entities involved are sometimes qualitatively different in nature. For example, in studying the sharing of food, it is straightforward to measure the caloric value of the food but it is more difficult to measure the “social value” ascribed to the sharing. However, by examining the predictions of various sociological models and comparing them to observation, qualitative assessments can sometimes be made to support or reject hypotheses. Simulation is especially helpful in this regard in that it enables systematic examinations of the effects of different behavioral models with a comparison to what is found in real-world societies. In this paper we examine three topics — sharing, tolerance, and violence — and compare the results of simulations to observations of egalitarian societies.

METHODOLOGY USED IN THE SIMULATIONS

A detailed description of the simulation method used here can be found in Younger (2003, 2005a,b); the last reference contains pseudocode of the major algorithms. We modeled a population of 100 agents on a 20×20 grid containing five sources of food. The simulation proceeded through a series of time steps in which agents decided their individual course of action on the basis of their hunger and their relationships to other agents.

The food sources were replenished at a rate of 20 food units per time step so that an average population of 100 agents could be sustained. Food was enduring, so food units not used in one time step remained for use in the future. Agents moved around the landscape in search of food, and when they found a food source, they remembered its location and the amount of food present. Agents could sense food and other agents to a distance of five squares in each direction, a sensory range that prevented them from seeing the entire environment at one time. When an agent was at a food source, it consumed food so that its hunger was reduced to zero and collected up to 100 food units to carry for later consumption.

An agent required one unit of food per time step and died of starvation if its need for food exceeded 200 points. The maximum age to which an agent could live was 4,000 time units. All simulations reported here were run for 40,000 time steps or 10 agent lifetimes, and the results in the tables and figures are averages of 20 such runs.

Agents were divided into two normative categories: sharing and stealing. Sharing agents shared whatever food they carried with all collocated agents; stealing agents who were not carrying food stole food carried by another collocated agent. (A more complex algorithm including theft was used in some scenarios and is described below.) An interaction matrix, $imx(j,k)$, tallied agent interactions. When agent k shared with agent j , the amount shared was added to $imx(j,k)$. When agent k stole from agent j , the amount stolen was subtracted from $imx(j,k)$. The interaction matrix element thus represented a form of normative reputation of agents. When two agents met, they shared normative reputations of all other agents by averaging the interaction matrix elements connecting them to those other agents. The sum of all of the interaction matrix elements connecting agents in the population was termed the mutual obligation and represented the sharing-generated social cohesion of the model society.

Female agents chose a mate upon reaching the reproductive age of 1,000 time units. They chose the unmatched male with whom they had the highest interaction matrix element. Mating was monogamous and for life. At each time step, there was a probability of conception, set

to 0.004. Offspring were born immediately, with no gestation period, and had no knowledge of other agents or of the landscape. The normative character of the mother (sharing or stealing) was inherited by the new agent.

More information on the model and the effect of various choices of parameters can be found in Younger (2005a,b).

RESULTS OF SIMULATIONS COMPARED TO OBSERVATIONS OF EGALITARIAN CULTURES

Sharing in Small Societies

Sharing was a ubiquitous phenomenon in egalitarian societies. In societies where the acquisition of food was sporadic and occurred in large parcels, such as those that hunted game too large to be consumed by an individual or family unit, sharing helped ensure that everyone was fed regardless of who felled the prey. In many other situations, notably in the case of resource-rich tropical islands, there was no need to share, yet sharing occurred all the same. Sharing served to create a network of mutual obligation within the society that was an important component of social cohesion. When every person was in some way indebted to every other person, there was an enhanced sense of belonging and an expectation that one would be cared for in a time of need. This attitude was exemplified among the Semai of Malaysia (Robarchek and Robarchek 1992), who regarded belonging to the group as an essential element of life in an uncertain world.

There are a number of means by which people can choose to share — from indiscriminant sharing that is independent of the sharer’s relationship to the recipient to focused sharing done in expectation of comparable return. Taken to its extreme, the later form of sharing approaches trade. To examine various types of sharing, we simulated a society of 100 agents that either shared or did not share. (There was no theft in this scenario.) Non-sharers represented “free riders” who derived benefit from others without the cost of contributing any food of their own. The initial population was evenly divided between sharers and non-sharers. Four models were examined:

- Indiscriminant sharing wherein an agent shared with whoever was at the same location, regardless of relationship or past history;
- Sharing only with the head of a household;
- Sharing only within the sharer’s family unit (mother, father, spouse, offspring, sibling); and
- Sharing only with other sharing agents.

The results of the simulations are given in Table 1. We found the mutual obligation, which in our model represented sharing-generated social cohesion, was maximized for indiscriminant sharing. In each of the other cases, less sharing occurred, so that the network of mutual obligations generated by the receipt of gifts from others was reduced.

TABLE 1 Mutual obligation for various models of sharing within a gathering society

Model for Sharing	Mutual Obligation	Standard Deviation
Indiscriminant Sharing	330	58
Sharing Only with Head of Household	160	21
Sharing Only within Family	190	21
Sharing Only with Other Sharing Agents	210	20

Bliege et al. (1997) did a quantitative study of sharing of hard-to-obtain turtle meat on Mer Island, located in the Torres Strait off the northern coast of Australia. In that resource-rich environment in which an individual could easily satisfy his needs and in which sharing was not required, they found that hard-to-obtain turtle meat was shared with whomever happened to be nearby, regardless of kin or social relationship. In fact, the probability of sharing was inversely proportional to the distance of the sharer to the potential recipient. There was no attempt to direct meat to those who might provide some future advantage, such as the families of prospective marriage partners, and there was no consideration of whether the recipient had ever shared with the giver.

Kaplan and Hill (1985) observed a similar pattern among the Ache of Paraguay. They found that sharing did not follow an inverse relationship with kinship. They did not find that non-sharers received less of a share than sharers. The simulations thus support the observations that sharing in egalitarian cultures played an important role in building solidarity within a population.

Tolerance

All societies possess a set of behavioral norms that govern the actions of individuals and, in many cases, groups. A key question in evolutionary social dynamics is whether there is a preferred set of normative guidelines that improve the survival probability of a population. Boehm (1999) notes that the normative systems of egalitarian people the world over are remarkably similar and, in particular, that they all seem to display a remarkable intolerance to non-normative behavior. For example, it is common in such cultures that transgressions are immediately responded to by the aggrieved party, sometimes by ridicule and sometimes by violence. Most often, such sanctions are conducted at the individual level, between the two people involved, rather than at the group level. Why is this, and why don't such people display more tolerance toward non-normative behavior?

We investigated this issue by simulating a population of 100 agents, the initial group being equally divided between those who shared and those who stole. Further, we made the selection of mates dependent upon the reputation of the agents. When it came time for a female to mate, she chose the male with whom she had the highest interaction matrix element, which in our model represented the reputation of the agent. If the prospective mate had a reputation below a certain tolerance level, treated as a variable in the simulations, then that agent would be

rejected as a mate. Thus one would expect agents who shared frequently to have a high reputation and hence have a high probability of being chosen as a mate. Conversely, an agent who stole would have a lower probability of being chosen. Note that sharing and theft had opposite near-term and long-term consequences. Sharing detracted from short-term survival in that food was given away, but there was a long-term advantage in finding a mate. Stealing increased the short-term survival probability by allowing an agent to take food from another, in essence providing another source of food, but there was a long-term disadvantage in finding a mate. Figure 1 shows the survival probability of the total population vs. the tolerance level.

The population survived when tolerance was either very low or very high. In between, there was a significant probability of population collapse. For low tolerance, agents with a reputation for theft were effectively excluded from the mating pool and were thus unable to pass along their “theft gene” to the next population. Over several generations the population evolved to include only sharing agents. (Recall that sharing and stealing behavior was inherited from the mother.) Conversely, when tolerance was very high, there was no long-term advantage to sharing, and the short-term advantage of theft prevailed. In between, we found that the subpopulation of sharing agents disappeared as a result of being preyed upon by thieves and that once those sharing agents were gone, the stealing agents could not find mates among themselves. This effect is illustrated in Figure 2, which shows the fractions of sharing and stealing agents vs. tolerance.

While our model is simple compared to human egalitarian societies, it demonstrates that tolerance to transgressions can have negative effects when reputation is important in mate selection. It is interesting that all known egalitarian societies practice strict intolerance to individual transgressions, in accord with the results of the simulations.

Homicide and Revenge

Homicide and revenge were significant contributors to adult deaths in many egalitarian societies. It was not uncommon for homicide and warfare to account for several tens of percent

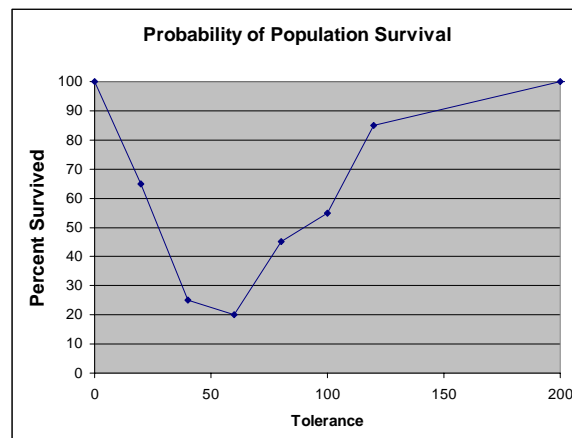


FIGURE 1 Probability for survival of the population until the end of the run

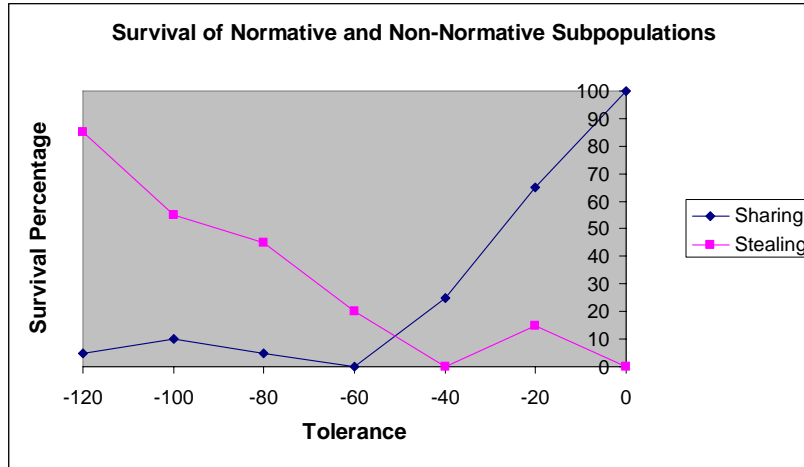


FIGURE 2 Fraction of sharing and stealing agents as a function of tolerance

of all adult deaths (Keeley 1996). For example, among the Gebusi of New Guinea, Knauff (1987) found that about one third of all adults died as a result of violence. Among the Waorani of the Amazon, the homicide rate was over 60% (Yost 1981). Patterns of violence varied widely among indigenous peoples. Otterbein (2000) found that only a fraction of the societies in his cross-cultural study killed females captured in raids. On the other hand, the Gebusi killed men, women, and children with equal frequency. Boehm (1999) conjectures that many societies proscribe violence within the social group, but Kelly (1987) finds that violence with the residential community is common. Merely stating that these differences are “cultural” ignores the question of whether there is some underlying systemic reason for them.

We simulated two types of violence in a population of 100 agents: homicide committed during the act of theft, and violence committed in revenge for a previous transgression. The agents were divided into two equal social groups. In this simulation, we employed a version of “situational ethics,” wherein an agent would share if its hunger relative to the maximum allowed before starvation was less than an altruism parameter A . An agent stole if its hunger was greater than its altruism parameter and more than the quantity $(1 - G)$, where G was an aggression parameter. Both A and G were in the interval zero to one, so that agents with high A were likely to share and agents with low A and high G were likely to steal. The success of a theft depended on G and another parameter, F , which described the fighting ability of the agent. If the attacker had higher G and F , then theft occurred without fighting. If the defender had higher G and F , then no theft occurred. If the attacker was more aggressive (higher G) but had less fighting ability (lower F), then it died in the attack. If the attacker was less aggressive but had greater fighting ability, then the attacker killed the defender and took the defender’s food. In this scenario, we did not make reputation a factor in mate selection.

Revenge occurred when an agent encountered another agent against whom it held a negative reputation. Here the agent with the higher fighting ability won the conflict. Whenever a killing occurred, whether during theft or by revenge, an amount equal to an agent lifetime was deducted from the interaction matrix element of all members of the victim’s village who were

collocated with the killing. This could result in a cycle of revenge, wherein one killing would be in revenge for a previous one, with the original cause of the dispute long forgotten.

The results are given in Table 2 and demonstrate that without excluding some major portion of the population from homicide and revenge, there is a significant probability of population collapse. It mattered less what portion was excluded as long as there were enough members in that portion to limit the total amount of violence.

Not all transgressions are serious enough to result in blood revenge. We studied tolerance before revenge and found that even small amounts of tolerance — less than what would be required to forgive a single theft — were sufficient to greatly reduce the rate of violent deaths. We also studied the effect of higher population density on the murder rate and found that, while violence did increase, its negative effects were overtaken by the positive effects of more frequent interactions between agents.

Ecological factors sometimes result in increased non-normative behavior within a population. The Ik of Uganda are an example of a population for whom the norms of sharing and group solidarity broke down when the traditional hunting grounds of the tribe were deemed off limits. In this case, family members kept food to themselves and stole from others; the spirit of cooperation almost completely disappeared (Turnbull 1972). We simulated this effect by reducing the amount of food that replenished the food centers in our environment and found that the result was a significantly increased rate of killing committed in the act of theft. A comparison of the results of simulations to ethnographic observations is given in Table 3. These and other results of simulations of violence and revenge in egalitarian societies are discussed in more detail in Younger (2005b).

TABLE 2 Results of excluding different segments of the population from violence and revenge^a

Subpopulation Excluded from Violence	None	-	-	Fa	-	Fa	Fa	Fa
	-	-	G	-	G	-	G	G
	-	Fe	-	-	Fe	Fe	-	Fe
Survival rate (%)	35	40	30	10	60	35	55	90
Deaths due to old age (%)	70	75	68	71	71	71	71	74
Deaths due to hunger (%)	4	13	4	3	16	17	18	19
Deaths due to violence (%)	12	3	11	8	3	3	4	2
Deaths due to revenge (%)	14	9	17	19	10	9	7	5
Total mutual obligation	380	330	400	420	340	310	430	370

^a Fa means that violence and revenge were forbidden within the family, G within the group, and Fe among females. The last column represents a situation where violence and revenge were permitted only against males of the other social group. Each entry represents an average over 20 runs, where only those runs that had a nonzero population at the end of the run were included in the average.

TABLE 3 Comparison of simulations of homicide and revenge with ethnographic observations

Simulation Result	Ethnographic Observations	Comments
Violence and revenge contributed substantially to mortality and reduced the overall survival rate of the population.	Violent deaths accounted for tens of percent of the total recorded deaths among the Copper Eskimos, Gibusi, Waorani, and other indigenous peoples.	Violence is a population control mechanism in some egalitarian societies.
Excluding significant segments of the population from violence and revenge improved the survival rate of the total population.	Kapauku excluded females from violence. There is little violence among females in Kunimaipa society. Some primate and human societies proscribe violence within immediate social group.	Many societies discourage violence among significant parts of the population.
Tolerance before revenge increased the survival rate of the total population.	Peaceful societies (e.g., Semai) have high levels of tolerance. Violent societies (e.g., Yanomomo) have low levels of tolerance.	Tolerance reduces the rate of revenge killing.
Increasing the population density increased the survival rate of the total population, even though revenge killings increased.	Keeley (1996) found that population density and the rate of violence were not correlated.	A higher survival rate in simulations is a result of more mating opportunities. Simulations omit control mechanisms that limit violence in real societies.
The rate of violence increased when food scarcity was introduced.	Scarcity reduced sharing within a group and, in extreme circumstances, increased antagonism and theft within the group. The Ik of Uganda are a particular example of theft increasing in times of scarcity.	Scarcity of food increased the rate of violence, consistent with ethnographic observations.

DISCUSSION

Simulation provides a useful methodology for testing various assumptions about relating normative behavior to small societies. In particular, rule-based simulations allow hypotheses to be tested in a systematic manner and the results compared to real societies. If the simulation agrees with nature, then there is support for the hypothesis. If there is substantial disagreement, then one must look at the underlying assumptions in the model to find the cause. While our simulations are very simple compared to even the “simplest” human culture, and while the detailed modeling of human behavior must cope with the fundamentally stochastic nature of social interactions, they may still provide a framework to help improve our understanding of how individuals and societies behave. In this sense, simulations are analogous to cross-cultural studies

of real societies in that the conclusions are general rather than specific to one society. However, it is also possible to model a single society in detail, including realistic birth rates, food sources, and behavior patterns. Such a simulation of a Pacific society is in progress and will be described in a later report.

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